

Application for United States Patent

of

John Steven Langford, *et al*

Switch-user Security for UNIX Computer Systems

5 CROSS-REFERENCE TO RELATED APPLICATIONS

(CLAIMING BENEFIT UNDER 35 U.S.C. 120)

Not applicable.

FEDERALLY SPONSORED RESEARCH

AND DEVELOPMENT STATEMENT

10 This invention was not developed in conjunction with any Federally
sponsored contract.

MICROFICHE APPENDIX

Not applicable.

INCORPORATION BY REFERENCE

15 Not applicable.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to the arts of computer user security and access control technologies, especially to those employed in UNIX and UNIX-like operating
5 systems.

Description of the Related Art

The UNIX operating system, in all its varied forms and including similar operating systems, is a powerful tool upon which to base mission-critical applications. Its security, scalability, and robustness have led it to withstand the tests of time, and
10 today, the majority of web servers are hosted on UNIX computers. Despite all of its strengths, however, methods exist to take advantage of its capabilities. Eliminating, or at least mitigating, the possibility of malicious actions is a major goal for UNIX system administrators.

One aspect of the UNIX system which may be open to manipulation is that of
15 a user switching IDs ("SU'ing") to a different user. In some cases, this may be done maliciously. In less than fifteen seconds at an unguarded root console, a malevolent user could enable SU functionality for his or her ID. Subsequently, that user could take on root authority on the machine, and either view or destroy sensitive data upon the system which is privileged to the root user, but not to the malevolent user's normal
20 ID.

Such "user switching" could also be done accidentally through a slip of the finger, or an authorized system administrator could inadvertently grant SU authority to a user.

Regardless of whether the switch is accomplished maliciously or accidentally,
5 the effect is the same, in that the impacted user now has complete control and privileges over the entire system.

Two means exist for the administrator to uncover that such authority has been granted and/or used. The system administrator can manually review the characteristics of each individual user ID's. As large organizations often have
10 hundreds or even thousands of users configured to use their systems, such periodic checks are not practical.

The second method which can be used is a visual inspection of the "SULOG" file, which contains a history of the "switch user" activities. Since this file can be extremely large, and is buried down within the system directory structure, inspection
15 of the SULOG occurs seldom, if ever. Typically, an administrator is usually far too occupied with other responsibilities to check this file regularly.

It should be noted that SU authority can be granted in order to give a specific user the ability to switch to the root ID, or it can be granted to give users access to other ID's as well. Frequent examples of the latter include permitting certain users to
20 switch their log-in to an "oracle" ID or a "backup" ID. Since such ID's often have expanded and critical functions and data available to them, it is also important to watch for such activity as this as well.

Therefore, a user who has been granted a low-level or restricted level of privileges or "permissions" may be his assigned initial login ID, but then he may obtain a higher level of privileges through doing a SU operation to the root ID. This is currently very difficult to track or detect given the default functions available in UNIX
5 or other UNIX-like operating systems.

Therefore, there is a need in the art for a system and method to monitor unauthorized user switching or user substitutions on UNIX-based and UNIX-like systems so that appropriate corrective actions may be taken upon the detection of unauthorized user switching activities. This system preferably should be easily
10 implement able by system administrators without significant changes to the operating system or user ID's that are already defined. Preferably, the system and method shall provide a remote notification function in order to notify a system administrator of a detected violation, such as an email notice.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description when taken in conjunction with the figures presented herein provide a complete disclosure of the invention.

5 FIGURE 1 sets forth the general architecture of UNIX-based computer systems.

FIGURE 2 illustrates the logical flow of the user-switch monitoring script or process.

10

SUMMARY OF THE INVENTION

A monitoring process is disclosed for defining and detecting user-switch violations and issues in a UNIX-based computer system periodically alerts system administrators of potential security risks. The monitoring process is preferably
5 executed at predetermined schedules, or invoked by manual command. A set of rules is defined by the system administrator, and any user-switch instances found in the UNIX user-switch log which match any rule are flagged as violations or potential security issues, and an alert notification is issued to a specified output device such as an email address.

10 The violation rules are conveniently defined in a text file, and the UNIX scheduling daemon CRON is configured to periodically execute the monitoring script in the preferred embodiment. Thus, a system administrator may configure the rules, the periodicity of monitoring, the alert output destination, and even the source user-switch log file, thereby allowing maximum flexibility for the system
15 administrator to find and detect a wide variety of possible security issues.

DETAILED DESCRIPTION OF THE INVENTION

The UNIX operating system and similar operating systems such as IBM's AIX, BSD, Hewlett Packard's HP-UX, LINUX, and SUN Microsystems' Solaris operating systems are all viable alternatives for implementation of the current invention. As
5 these operating systems are well-known in the art, the invention disclosed herein will be described relative to UNIX in a general manner. It is well within the skill of those in the art to adapt the disclosed invention to a particular UNIX-like operating system.

Turning to Figure 1, the generalized architecture (1) is shown of a UNIX-based computer system. The hardware platform (2) typically comprises a central
10 processing unit or microprocessor, system memory and user interface devices such as keyboard, displays, pointing devices, and multimedia peripherals. The hardware platform may be a personal computer, or a multi-user server class computer. The UNIX kernel (3) provides system management functions which manage system memory for executing software processes and daemons. The kernel (3) also manages
15 the system hardware devices, schedules the execution of all commands, and contains device drivers that control the system hardware. Device drivers are device-specific software modules and files which allow the software processes and system daemons to interface to the hardware platform components, such as disk drives, network interface cards, the display, and printers.

20 The UNIX shell (4) is the user interface command line component of the system which allows commands of a simple nature to be input to the system.

Commands which are input through the shell (4) are passed to the kernel (3), software processes, or system daemons for processing and execution.

Some Unix-based systems are provided with a graphical user interface ("GUI") or common desktop environment ("CDE") (5) which provides a more user- friendly interface, such as a windowing environment.

Additionally, some UNIX systems, such as workstations, have direct user interface devices (6) such as keyboards, monitors, and pointing devices. However, some UNIX based systems are networked to a computer network (7) through various forms of well-know network interfaces, such as Ethernet cards and modems, which allow the UNIX-based system (1) to be shared among multiple users who are remotely located. Almost all the UNIX-based systems are provided with system disks, such as hard drives (9).

In the preferred embodiment, the invention is implemented on a UNIX-based system as shown in FIGURE 1, and the logic of the invention is implemented as a script which is executed upon a predetermined schedule and/or upon specific invocation by the system administrator.

The script, which is described in more detail later, is executed on a predetermined schedule preferably by the system's "CRON" daemon. The CRON daemon is a common UNIX system daemon which reads configuration files, and acts on their contents. This is a convenient method of running the SUMON script on a periodic basis, but is not the only possible implementation for such periodic execution of the script. For example, the script could be self-timed, running in a loop until the

system clock reached predetermined values, or it could be assigned to a system timer interrupt. As such, the use of the CRON daemon is an aspect of the preferred embodiment but is not a limitation of the present invention.

Typically, the CRON configuration files contain the command or commands
 5 to be executed, the day, date and time to run the commands, and the user name(s)
 under which the command(s) should be executed. These configuration files are called
 "CRONTAB" files in most UNIX-like systems.

The CRON daemon and CRONTAB files are well-known within the art. Thus,
 in the preferred embodiment, a script is provided on a UNIX-based system, which is
 10 then scheduled through the use of a CRONTAB file to be executed by the CRON
 daemon on a periodic basis. This frees the system administrator from the need to
 periodically or regularly monitor the SLOG file. However, should the system
 administrator desire to run the invention at any time, he may invoke it through a
 simple command line input.

15 The user switch (or user substitution) monitoring script, which is referred to as
 "SUMON", is configured by a CRONTAB file to be executed periodically, such as
 once per day, as shown in the example of TABLE 1.

Table 1: Example CRONTAB file contents

20 `<time> sumon -f <sourcefile> -e <emailaddress> -r <rulesfilename>`

As shown in Table 1, <time> specifies the minutes, hours, day of the month, month, and day of the week to execute the SUMON script. For example, to schedule CRON to run the SUMON script once daily at 11:55 PM, the parameter <time> would

5 be set to "55 23 * * * ", where the wildcard characters " * " indicate any day of the month, any month, and any day of the week.

Further as shown in Table 1, the "-f <sourcefile>" parameter specifies the file in which to search for SULONG information. If omitted, the system default SULONG file is searched, such as "/var/adm/syslog".

10 The parameter "-e <emailaddress>" specifies an e-mail address where alert messages are to be sent if an alarm condition is detected. If this parameter is omitted, the alerts may be sent to a default e-mail address, such as root@<host_name> where <host_name> is the name of the host computer on which the SUMON script is running.

15 The parameter "-r <rulesfilename>" specifies the file containing a list of user switching conditions which will trigger the alert notification.

For reference, Table 2 illustrates an example of an SULONG, which contains the history of the "substitute user" command usage on the system. SULONG, or it's equivalent, is created automatically by the system kernel each time a user invokes the

20 SU command.

Table 2: Example SULONG file contents

5 SU 07/05 15:29 + pts/2 notes-root
SU 07/07 15:17 + pts/1 root-root
SU 07/07 15:17 + pts/1 root-notes
SU 06/31 09:25 - pts/1 notes-root
SU 09/08 08:56 + pts/1 root-root
SU 09/08 09:06 + pts/3 notes-root
10 SU 09/08 09:06 + pts/3 notes-root

The example of an SULONG given in TABLE 2 is very brief compared to typical SULONG files found on real UNIX-based systems. Most SULONG files contain hundreds or even thousands of entries, in practice, for a single day's activities.

15 An alarm conditions file, or "RULES" file, contains definitions for times or time ranges in which to search the SULONG for violations, user switching conditions considered a violation, and how many violation instances may be tolerated before creating an alert. For example, a system administrator may want to receive alerts for the following user switching conditions:

- 20
1. if ANYONE switches to ROOT;
 2. if ANYONE switches ANY OTHER SPECIFIED ID;

- 3. if a SPECIFIC USER switches to another ID between CERTAIN HOURS; or
- 4. if a SPECIFIC USER switches over an absolute number of occasions within a set window of time.

5 TABLE 3 shows example contents of a RULES file. If any of the specified rules, which are set by the system administrator, are detected as broken when the SUMON script is executed, then alerts are sent to the specified e-mail address (typically configured to point to the system administrator's e-mail address).

10

Table 3: Example Rules file contents

15

<u>from-id</u>	<u>to-id</u>	<u>time-start</u>	<u>time-stop</u>	<u>occurences</u>
*	root	*	*	-1
batch	oracle	0600	1700	-1
joe	backup	*	*	5

20

The first line of the example RULES file specifies that a switch from any ID to ROOT, at any time, is a violation. The "-1" signifies that any occurrence of this situation is not tolerable.

In the second line of the example rules file, another violation is defined as any time the BATCH ID is switched to ORACLE between 6:00 AM and 5:00 PM.

In the third line of the example rules file, yet another violation is defined as any time user "joe" switches to the BACKUP ID more than 5 times within the
5 SLOG file. This type of rule may be useful for detecting switches which are normally allowable, but when made too often may indicate a security issue. The system administrator may control the length of the time in which 5 switches are allowed by clearing the SLOG periodically.

So, as previously described, a SUMON script is used to implement the logic
10 which searches the SLOG for entries in the log file which violate the rules as established in the rules file. A UNIX script file or "shell script," contains a series of commands within a file which can then be executed by manual invocation or by automatic system invocation. Scripts are well-known within the art, and are commonly used to automate manual series of actions taken at the shell level. Scripts
15 can contain commands to execute loops, IS-THEN statements, as well as other commands. Also, scripts can accept parameter input tasks into the script for processing from the command line or from the script file.

Turning to FIGURE 2, the fundamental logic of the SUMON script is disclosed. After the system has been initialized (21), the SUMON script is scheduled
20 (22) to be executed by the CRON daemon by specifying an appropriate CRONTAB file, such as that shown in TABLE 1. Then, the UNIX CRON daemon continually monitors (23) the system clock to determine if it is time to run the SUMON script.

When it is time to execute the SUMON script (or when the script is manually invoked by the system administrator), the first rule is read (24) from the RULES file (25). Then, the SLOG (27) is searched (26) for any entries that match or violate the current rule. If an entry is found (28) that matches the current rule, an output alert is
5 created (29), such as an email message to the specified email recipient or an entry into alert file.

Next, the RULES file (25) is checked (30) to determine if any additional rules are to be checked. If additional rules exist, then the next rule is read (31) and the SLOG is searched (26) again for matching entries.

10 Once all of the rules have been processed (30) the SUMON script terminates execution and is not run again until the CRON daemon detects that it is time to execute the SUMON script again (23), or until it is manually invoked by the system administrator.

Thus, by periodically and automatically reviewing the SLOG using the
15 SUMON script as disclosed, security for the UNIX environment is increased, and the system administrator is relieved of the tedious job of looking through hundreds to thousands of SLOG entries find any one of many possible violation conditions. It will be recognized by those skilled in the art that many variations, changes and alternatives may be used in the implementation of the invention, such as
20 implementation of the SUMON function as a C++ or Java program, use of another operating system, etc., without departing from the spirit and scope of the invention.

As the description given herein is intended for illustrative purposes, the scope the invention should be determined by the following claims.

1. A method of determining a value of a function $f(x)$ at a point x by using a set of basis functions $\{b_1(x), b_2(x), \dots, b_n(x)\}$ and a set of coefficients $\{c_1, c_2, \dots, c_n\}$ such that $f(x) = c_1 b_1(x) + c_2 b_2(x) + \dots + c_n b_n(x)$.